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(54) COLD ROLLED STEEL SHEET EXCELLENT IN FORMABILITY AND RIGIDITY AND ITS MANUFACTURE

(57)Abstract:

PURPOSE: To provide a cold rolled steel sheet excellent in formability and rigidity and to provide its manufacturing method.

CONSTITUTION: Steel contg. specified C, Mn, Al, Nb and Ti is hot-rolled in limited conditions, cold-rolled at a prescribed draft thereafter subjected to a recrystallization annealing or an inline annealing type continuous galvanization to obtain the objective cold rolled steel sheet excellent in formability and rigidity. This cold rolled steel sheet has ≥35% high ductility and ≥ 1.5 high average (r) value as well as having ≥240GPa high Young's modulus in a direction perpendicular to the rolling direction.

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1]Cold rolled sheet steel excellent in a moldability and rigidity having not less than 35% of total elongation, and 1.5 or more an average of r values, and having the Young's modulus of 240 or more GPa in the direction vertical to a rolling direction.
[Claim 2]C :0.0003 - 0.010wt% and Mn:1.2 - 2.5wt%, Steel which contains at least one of Ti:0.005 - 0.10wt% of sorts, and consists of the remainder Fe and inevitable impurities aluminum:0.005 - 0.10wt% and Nb:0.005 - 0.10wt% With a piece of heat, After inserting in a heating furnace and heating at not less than 1050 **, in rough rolling, in a 980-1100 ** temperature requirement Or per one pass, Apply not less than 20% of large pressing down once [at least] or more, and finishing rolling is ended at Ar_3-930 **, A manufacturing method of cold rolled sheet steel excellent in a moldability and rigidity cold-rolling and carrying out recrystallizing annealing of what made the amount of bottoms of total pressure not more than [in finishing rolling] Ar_3+150 ** not less than 85%, and was rolled round at room temperature - 800 ** with rolling reduction of not less than 30%.
[Claim 3]A manufacturing method of cold rolled sheet steel excellent in a moldability according to claim 2 and rigidity carrying out after [cold rolling] in-line annealing type continuation hot dip zincing.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application]This invention is a thing about outstanding cold rolled sheet steel of press-forming nature and rigidity, and a manufacturing method for the same, Since it has high Young's modulus in the still more detailed direction (the direction of C) ductility and an average of r values are high, and are vertical to a rolling direction, it is related with cold rolled sheet steel which can improve the rigidity of parts or a product, and a manufacturing method for the same.

[0002]

[Description of the Prior Art]Since the main uses of steel sheets were in the Body Manufacturing Division article etc. of the car which performs press forming, the chief aim was conventionally placed by only development of the steel plate which was excellent in deep drawability. However, especially body-weight mitigation of a car attracts attention from a viewpoint of the fuel consumption improvement of the car which made global environment problems the beginning, and importance is attached to reducing the board thickness of the steel plate which constitutes the body these days.

[0003]In this case, that the tension rigidity of forming parts falls poses a problem by the thinning of a steel plate. If power is applied to forming parts from the exterior, the deflection by elastic deformation will arise, but the resistance force to this deflection generating stretches, and it is rigidity. The tension rigidity needs to use a steel plate with high Young's modulus for reducing board thickness, with tension rigidity maintained, in order to be dependent on the Young's modulus and board thickness of a steel plate.

[0004]There are JP,62-33290,B, JP,57-181362,A, and JP,58-9932,A as production technology of high-Young's-modulus cold rolled sheet steel. Although characterized by JP,62-33290,B adding P 0.03 to 0.12% as an ingredient which raises Young's modulus, since a moldability,

especially the fracture toughness in secondary elaboration are spoiled by addition of P, it feels uneasy that it is difficult to apply to difficulty forming parts like the panel of a car.

[0005]Although rigidity is improved in JP,57-181362,A by enlarging addition of P, and thickness of the board width center section of the steel plate, Unless in addition to the problem of secondary elaboration brittleness the board with uneven thickness is difficult to manufacture and the still more nearly special device at the time of press working of sheet metal is given, it is difficult to obtain the shape of the complicated parts of a car. The main azimuth components (110) of texture JP,58-9932,A. Although the manufacturing method of a certain steel sheets is indicated by [001], since this steel plate has an average of r insufficient values which are the indices of ductility or deep drawability, it does not bear press working of sheet metal with severe autoparts.

[0006]Although it is a shell and an inner plate that stretch by autoparts and rigidity poses a problem, these are manufactured by severe press working of sheet metal. Since it was only having satisfied rigidity and each above-mentioned conventional technology had the large problem in respect of a moldability, the application as a material for inner and shells was dramatically difficult. That is, the material for inner and shells is required to be compatible in a moldability and rigidity.

[0007]

[Problem(s) to be Solved by the Invention]This invention is making high Young's modulus of a direction (the direction of C) vertical to a rolling direction while making high ductility and an average of r values, and an object of this invention is to provide cold rolled sheet steel excellent in a moldability and surface rigidity. What performed the surface treatment is included with cold rolled sheet steel here.

[0008]

[Means for Solving the Problem]It was thought that the improvement beyond it could seldom expect Young's modulus of the iron polycrystalline substance by about 210 GPa conventionally. However, since Young's modulus of a single crystal serves as maximum abbreviation 290GPa in the <111> directions, Young's modulus of the specific direction of [within a field of a steel plate] can be made high by controlling texture by a component and a manufacturing process of steel. By coinciding a direction with high Young's modulus in the direction which needs the rigidity of parts or a product, even if it makes board thickness thin, sufficient rigidity can be obtained.

[0009]JP,1-41689,B is indicating a manufacturing method of Takahira ** r value hot rolled sheet steel. When this invention persons promoted research wholeheartedly, it became clear by adding cold rolling and recrystallizing annealing to this that it becomes possible to raise an average of r values further, and Young's modulus of the direction of C can be raised for the first time. On the other hand, a severe moldability is also required of a panel part of a car.

[0010]In order that this invention may solve an aforementioned problem, steel which contains 1.2 to 2.5% of Mn based on extremely low carbon steel which added at least one sort of Nb and Ti, Large pressing-down rolling is performed in the specific temperature range in an austenite region, and it cools after that, and rolls round at a specific temperature, and also cold rolling and recrystallizing annealing, or a means that carries out hot-dip-zincing processing is adopted.

[0011]That is, it is already known that deformation texture of gamma iron will progress if it rolls in the low-temperature non-recrystallizing temperature range of an austenite region, and transformation texture which will consist of {311} <011> and {332} <113> if this metamorphoses into alpha iron will progress. If cold-rolling and recrystallizing annealing are furthermore given by making these into an initial direction, a mechanism is not necessarily clear, but texture which has {211 <011>} in the main direction and has {111 <112>} in a subdirection progresses. Since {211 <011>} directions have the <111> directions which Young's modulus consists of in the direction of C in a plate surface with the maximum, Young's modulus of this direction becomes remarkably high.

[0012]On the other hand, Young's modulus in the plate surface is comparatively high, and {111 <112>} directions have small plane anisotropy. Speaking of an r value which is an index of deep drawability, an r value of {211 <011}> of a rolling direction to the direction of 45 degree is remarkably high. {111 <112>} is a direction ideal for an r value. As mentioned above, in order to solve simultaneously a technical problem mentioned above, it is thought that such texture is the most preferred.

[0013]In JP,62-33290,B, P is added 0.03 to 0.12% as an ingredient which raises Young's modulus, and Mn is made into 1.2% or less. However, in this invention, without adding intentionally, P which injures processability adds Mn in 1.2 to 2.5% of range, in order to extend an unrecrystallized austenite region.

[0014]A gist of this invention Namely, C0.0003 - 0.010wt% and Mn1.2 - 2.5wt%, Steel which contains at least one of Ti0.005 - 0.1wt% of sorts, and consists of the remainder Fe and inevitable impurities aluminum0.005 - 0.10wt% and Nb0.005 - 0.1wt% With a piece of heat, After inserting in a heating furnace and heating at not less than 1050 **, in rough rolling, in a 980-1100 ** temperature requirement Or an one pass, Apply not less than 20% of large pressing down once [at least] or more, and finishing rolling is ended at Ar_3-930 **, It is in a manufacturing method of cold rolled sheet steel further characterized by cold rolling, recrystallizing annealing, or carrying out hot-dip-zincing processing, after making the amount of bottoms of total pressure not more than [in finishing rolling] Ar_3+150 ** into not less than 85% and rolling round at room temperature -800 **.

[0015]

[Function]The reason for limitation of constituent features is explained below, and this

invention is clarified further. In order to aim at improvement in processability, the lower one of C as much as possible is good. Although it was one feature that Mn of this invention steel is high, C pickup arose by ingot top Mn addition with steel manufacture, and the maximum of C was made into 0.010wt%, taking into consideration the case where the amount of C increases inevitably. The desirable range is 0.001 - 0.004wt%.

[0016]In the conventional cold-rolled-sheet-steel production technology, in order to secure deep drawability, Mn was judged as it is better to lower as much as possible. On the other hand, not falling deep drawability so much is also known in extremely low carbon steel. Mn is an element which lowers the gamma->alpha transformation point of steel effectively. Therefore, in order to carry out unrecrystallized rolling of the austenite by a finishing rolling stage, 1.2wt% at least is required. It ingots with steel manufacture, and also the maximum was made into 2.5wt% as a range which does not need special consideration. The desirable range is 1.2 - 2.0wt%.

[0017]The effect is lost as aluminum is required as a deoxidizer and it is less than [0.005wt%]. On the other hand, since a cost rise will be caused if 0.10wt% is exceeded, let this be a maximum. Dissolution with Nb or Ti harmful to prescription nature In this invention, Nb and Ti raise the recrystallizing temperature of austenite, and it not only adds, but [since [C N] are fixed,] they use extending an unrecrystallized austenite region positively by it. The required minimum quantity for that is 0.005wt%, and 0.1wt% is enough as it as a maximum. The desirable range is 0.02 - 0.05wt%.

[0018]Next, the reason for a numerical limitation is explained about hot-rolling conditions. The cooking temperature of hot-rolling shall be not less than 1050 **. This is for securing the dissolution Nb and Ti before a rough rolling start. Thereby, the recrystallization of austenite can be controlled at the time of finishing rolling. When 1050 ** can be secured as a temperature of a cast piece, it is not necessary to necessarily heat.

[0019]Rough rolling carries out rolling which applies not less than 20% per one pass of large pressing-down rolling once [at least] or more in a 980-1100 ** temperature requirement. At less than 980 **, it becomes unrecrystallized gamma grain, and, on the other hand, becomes a big and rough gamma grain above 1100 **. gamma grain will become coarse if the rolling reduction of an one pass will be less than 20% in all the paths. Therefore, rough rolling on the above-mentioned conditions is required.

[0020]A finishing rolled bar affair becomes very important on control of texture. Finishing temperature considers it as Ar_3-930 **, and makes the amount of bottoms of total pressure not more than Ar_3+150 ** not less than 85%. By less than Ar_3, since it becomes alpha region hot-rolling, desired texture is not obtained. Since a recrystallization gamma grain increases when it comes to more than 930 **, the rolling texture of gamma does not progress. In order to develop the rolling texture of gamma enough, it is necessary to make the amount of bottoms of total

pressure in an Ar_3-Ar_3+150 ** temperature region into not less than 85%.

[0021]The coiling temperature should just be 800 ** or less. It is because unusual grain growth will arise or degradation of the uniformity of the construction material in the direction of a coil length hand and degradation of pickling nature will occur, if it becomes more than 800 **.

[0022]Then, cold-rolled annealing conditions are described. Cold-rolled rolling reduction is made into not less than 30%. Rolling reduction is because the abnormal growth of a crystal grain arises during annealing at less than 30%. The annealing should just be more than recrystallizing temperature.

[0023]Not to mention manufacturing the steel plate which performed surface treatments, such as electrogalvanizing, to the annealing board, a continuous-annealing type hot-dip-zincing process is presented with a cold-rolled board, a hot-dip zinc-coated carbon steel sheet and an alloying hot-dip zinc-coated carbon steel sheet are manufactured, and even if it gives a rustproof function, the same effect is acquired.

[0024]

[Example]

(Example 1) Steel A-F which consists of an ingredient shown in Table 1 was ingoted in laboratory, and hot-rolling which can simulate system hot-rolling correctly was presented. Hot-rolling conditions are not based on steel, but are the same. Cooking temperature is 1200 ** and performed rough rolling (rolling reduction: -> [-> / 15% of / 25% of] 22%) of three paths from 100-mm thickness to 50-mm thickness in 1000-1100 **.

[0025]In giving finishing hot-rolling from 50-mm thickness to 4-mm thickness, Ar_3 temperature shown in Table 1 was referred to, and hot-rolling of 92% of the amount of bottoms of total pressure was performed in the Ar_3-Ar_3+150 ** temperature requirement, and it finished in the Ar_3-930 ** temperature requirement, and rolled round at 600 **. Continuous annealing was performed, after performing 80% of cold rolling after pickling and considering it as 0.8-mm thickness. continuous-annealing conditions -- heating heating-rate: -- they are 20 **/[s and], soak retention temperature:820 **, soak retention time:50s, and cooling-rate:20 **/s.

[0026]Temper rolling of the rolling reduction of 0.8% was performed after continuous annealing, and a tensile test and measurement of Young's modulus were performed. Tensile test conditions follow JIS Z 2241. It asked for Young's modulus using the resonance method. These evaluation results are shown in Table 2.

[0027]

[Table 1]

[0028]

[Table 2]

鋼	C	Si	Mn	P	S	Ti	Nb	Aℓ	N	Ar_3	備考
A	0.0025	0.01	0.8	0.032	0.010	0.02	0.05	0.04	0.003	869	比較鋼
B	0.0033	0.02	2.1	0.010	0.011	−	0.004	0.04	0.003	778	比較鋼
C	0.0155	0.01	1.3	0.007	0.007	0.04	0.02	0.05	0.003	820	比較鋼
D	0.0038	0.02	1.8	0.012	0.012	−	0.04	0.03	0.003	797	本発明鋼
E	0.0021	0.03	2.2	0.009	0.009	0.05	−	0.04	0.002	772	本発明鋼
F	0.0047	0.01	1.5	0.010	0.011	0.03	0.03	0.04	0.003	814	本発明鋼
G	0.0028	0.01	0.1	0.010	0.009	0.02	0.01	0.04	0.002	909	比較鋼

（成分値：wt%；Ar_3：℃）

鋼	YP	TS	El	r_L	r_C	r_D	$\bar{r}$	E_L	E_C	E_D
A	189	361	43	1.6	1.9	1.7	1.7	218	220	225
B	329	467	34	1.3	1.4	0.7	1.0	190	199	225
C	534	556	32	0.6	0.7	1.1	0.9	205	247	192
D	244	454	37	1.5	1.7	2.0	1.8	225	258	201
E	220	405	41	1.4	1.7	1.4	1.5	210	243	215
F	183	392	39	1.4	1.9	2.2	1.9	221	251	213
G	163	302	51	2.0	2.2	1.5	1.8	221	232	228

(YP, TS : MPa ; El : % ; E : GPa)

[0029]As shown in Table 2, the Young's modulus of the direction in which not less than 37% and an average of r have total elongation vertical to rolling as good as 1.5 or more of D of this invention steel, E, and F is 240 or more GPa. As compared with it of the comparison steel G and the comparison steel A (Mn being too low) and B (Ti and Nb being too low) of the cold

rolled sheet steel for the present deep drawing, and C (there being too much C) material, it is clear that processability and Young's modulus are remarkably good.

[0030](Example 2) After giving the process to cold rolling for this invention steel F which consists of an ingredient shown in Table 1, and the comparison steel C by the same technique as Example 1, It cooled, after heating to the maximum heating temperature at 820 **, and conventional hot dip zincing was performed at 460 ** (the Al concentration in a bath is 0.11%), and it heated further, and cooled to the room temperature in a second in about 10 ** /after 20-second suitable distance gold-ized processing at 520 **. Mechanical properties were evaluated about alloying galvanized steel sheet F' and C' which were obtained.

[0031]

[Table 3]

鋼	YP	TS	El	r_L	r_C	r_D	$\bar{r}$	E_L	E_C	E_D
C'	538	562	30	0.5	0.7	1.0	0.8	200	241	189
F'	188	398	36	1.4	1.7	2.0	1.8	213	242	207

(YP, TS:MPa; El:%; E:GPa)

[0032]As shown in Table 3, in an average of r, the Young's modulus of 1.5 or more and the direction of C satisfies [total elongation] 240 or more MPa simultaneously not less than 35%, and it is clear that this invention steel F"s balance of such weighted solidity is remarkably excellent compared with comparison steel C'.

[0033](Example 3) Hot-rolling which can simulate system hot-rolling was presented with this

invention steel F which consists of an ingredient shown in Table 1. Although cooking temperature is as common as 1200 **, rough rolling and a finishing rolled bar affair are as being shown in Table 4.

[0034]

[Table 4]

鋼	粗圧延条件 (%)	仕上げ圧延条件 (%)	冷延焼鈍板の特性値 r_L	r_C	r_D	$\bar{r}$	E_L	E_C	E_D
F-1	15→25→22	92	1.4	1.9	2.2	1.9	221	251	213
F-2	15→15→15→18	92	1.3	1.7	1.4	1.5	210	220	215
F-3	25→25→25	80	1.7	1.8	1.3	1.5	210	215	220

(E：GPa)

_____：条件・特性が本発明はずれ

E_L，E_C，E_D：それぞれ圧延方向から0°，90°，45°の角度をなす方向のヤング率

[0035]That is, a rough rolled bar affair separates from F-2, and the finishing rolled bar affair has separated from F-3 from this invention range. The rolling reduction in each path in a 980-1100 ** temperature requirement was shown in Table 4 as a rough rolled bar affair, and the amount of bottoms of total pressure in an Ar_3(814 **) -Ar_3+150 ** (964 **) temperature requirement was shown as a finishing rolled bar affair. Cold-rolling and an annealing process were presented with these hot-rolling boards by the same technique as Example 1, and characterization was performed.

[0036]It turns out that the rolling reduction and temperature in a hot rolling process are an important constituting factor of this invention so that clearly from Table 4.

[0037]The texture which is the feature of this invention steel was evaluated using the X diffraction. A valuation method is the technique of producing the {110} anode point figure about the board thickness central layer of an annealing board first, and analyzing the three-dimensional crystal orientation by a vector method continuously.

[0038]The Young's modulus of the direction of C and the intensity of closely related {211 <011>} directions were 2.3 and 1.9 respectively in F-2 of comparison steel, and F-3 to being 5.0 in F-1 which is this invention steel. On the other hand, the {111} facial strength with deep r value and relation was 5.7 and 4.9 respectively in F-2 and F-3 to being 8.7 in F-1. Thus, the feature of this invention steel is clear also seen from texture.

[0039]

[Effect of the Invention]This invention is the steel plate which was rich in ductility since it was IF steel, and was excellent in the moldability since an average of r values were high. Young's modulus is high in a direction vertical to a rolling direction, and the tension rigidity of parts can be improved by coinciding the direction of C of this invention steel plate in the direction with small curvature of parts. Therefore, since board thickness can be reduced without severe processing spoiling rigidity about required parts, the weight saving of the product can be carried out.

[Translation done.]